DOCUMENT RESUME

ED 157 733 SE 024 704

AUTHOR French, John C.; And Others
TITLE Agricultural Plant Pest Control. Bulletin 763.
INSTITUTION Georgia Dept. of Agriculture, Atlanta.; Georgia Univ., Athens. Cooperative Extension Service.
PUB DATE Sep 75
NOTE 48p.; For related documents, see SE 024 698-706; Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS *Botany; Disease Control; Environment; *Herbicides; Insecticides; *Instructional Materials; Manuals; *Pesticides; *Plant Pathology; Post Secondary Education
IDENTIFIERS *Pest Control

ABSTRACT

This manual gives general information on plant pests and pesticides. First, the life-cycle and habits of some common insect pests are given. These include caterpillars, beetles and beetle larvae, and sucking insects. Next, plant diseases such as leaf diseases, wilts, root and crown rots, stem cankers, fruit rots, seed and seedling diseases, and virus diseases, and nematode diseases are discussed. The control of weeds is also considered; this section includes perennial and biennial weeds, annual grasses, small-seeded broadleaf weeds, and large-seeded broadleaf weeds. Finally, pesticide formulation and application is discussed and a general description is given of some of the common bactericides, fungicides, nematicides, and herbicides. (BB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

ED157733

AGRICULTURAL

PLANT PEST CONTROL

SE 024 104

This manual was developed in cooperation with The Georgia Department of Agriculture

by:
John C. French, Extension Entomologist
Herbert Womack, Extension Entomologist
Sam S. Thompson, Extension Plant Pathologist
Charles W. Swann, Extension Agronomist, Weed Control

FOREWORD

This training manual is intended to provide you the essential information to meet Environmental Protection Agency standards on Agricultural Plant Pest Control, and to take the written examination for certification. The emphasis of the standards, and this manual, is on the principles of applying pesticides safely for man and the environment. All the training and information you need to do a good job of Agricultural Plant Pest Control is not included in this manual. Additional publications and shortcourses are available through the Cooperative Extension Service.

TABLE OF CONTENTS

FOREWORD

I. CROPS

II. PESTS
- A. Insects
  - 1. Caterpillars
    - a. Foliage and Fruit Feeders
    - b. Boring and Tunneling
  - 2. Beetles and Beetle Larvae
    - a. Weevils
    - b. Soil Feeding Larvae
    - c. Leaf Feeders
  - 3. Sucking Insects
- B. Diseases and Nematodes
  - 1. Leaf Diseases
    - a. Leaf Spots
    - b. Leaf Blights
    - c. Rusts
    - d. Powdery Mildew
    - e. Downy Mildew
  - 2. Wilts, Root and Crown Rots
    - a. Wilts
    - b. Crown Rots
    - c. Root Rots
  - 3. Stem Cankers
  - 4. Fruit Rots
  - 5. Seed and Seedling Diseases
  - 6. Virus Diseases
  - 7. Nematode Diseases
- C. Weeds and Weed Control
  - 1. Perennial and Biennial Weeds
    - a. Perennials
    - b. Biennials
  - 2. Annual Grasses
  - 3. Small-Seeded Broadleaf Weeds
  - 4. Large-Seeded Broadleaf Weeds

III. PESTICIDES
- A. Formulations and Sources of Information
- B. Application
- C. Insecticides
- D. Disease Control Chemicals
  - 1. Fungicides
  - 2. Bactericides
  - 3. Nematicides

E. Herbicides
1. Selective
2. Non-Selective
3. Contact
4. Translocated
a. Root Absorbed Herbicides
b. Foliage Absorbed Herbicides

F. Special Problems
1. Preharvest and Re-entry Intervals
2. Phytotoxicity
3. Residues
4. Environmental Contamination
a. Non-target Injury and Community Problems
b. Contamination of Soil and Water

I. CROPS

Agricultural crops are grown on large acreages of rather diverse land. Modern techniques of production of these crops require the use of large quantities of pesticides in order to produce the quantity and quality of products needed for the continued well-being of man. The productiveness of modern agriculture is truly one of the marvels of our time, and it is probably the most important underlying factor that makes the United States the most powerful country in the world.

Agricultural crops may be divided into field and forage crops, vegetable crops and orchard crops. The necessity of pesticides for maximum production of high quality products has been documented many times by research and experience. The quality of products grown without the use of pesticides is generally much lower, and in many instances, too poor to be accepted for market.

Proper care must be exercised in applying pesticides to all crops. Methods of application vary widely with some being more dangerous to the applicator than others. For example, spraying orchard trees where the pesticide is applied above the head of the applicator is much more hazardous than applying chemicals to a low growing field or forage crop.

When planting crops, consideration should be given to the pesticides that will be used during the production season, the methods of application that will be employed and whether either of these presents any problem for adjacent non-target areas that may be contaminated such as bodies of water, woodlands, urban areas and other crops. Every effort should be made in planning to at least minimize these problems, and prevent them if possible.

II. PESTS

A. Insects

Insects are the most abundant form of animal life on the face of the earth. There are far more different species (kinds) of insects than all other animals combined. Presently, over 800,000 different species are known to man and others are being described almost every day.

Relatively few of these different species of insects are considered to be economically damaging to agricultural plants. Species of beneficial insects outnumber damaging species.

Often damaging insects attack crops and many of them are capable of completely destroying the crop they infest. When damaging infestations occur, they must be controlled if losses are to be prevented. The most useful tool in controlling damaging populations of insects in crops is chemical insecticides. Other control procedures such as crop rotation, cultural practices, destruction of plant residues, planting dates and resistant varieties are useful in some instances.

The most important step in dealing with an insect problem is identifying the pest or pests involved. Extension workers can help in obtaining an identification. Once the insect is identified, information on its life cycle and habits, as well as the best methods of control,

can be obtained.

Some of the more important groups of insect pests are discussed briefly.

1. Caterpillars

Caterpillars are usually called "worms." There are many different species (kinds) that attack plants. There are four stages in the life cycle of a caterpillar. They are egg, caterpillar, pupa and adult. The adults are moths, butterflies or skippers.

Only the caterpillar stage causes damage. When they hatch from the egg, they are very small and, therefore, eat very little. As they get larger, they eat more and more.

Caterpillars are usually easier to control when they are small. As they get larger, most species are very hard to kill with insecticides. Good coverage of the area of the plant being fed on is usually essential to good control.

Caterpillars vary widely in color and markings. While a few species may be fairly consistent in their appearance, others vary drastically. Experience and training are essential to proper identification.

A few species of insects may feed on one kind of plant, or one group of similar plants, but many feed on a wide variety of plants.

a. Foliage and Fruit Feeders

This group contains more different species

of damaging caterpillars than any other. Some feed only on the foliage. Others feed only on the fruit, and still others feed on both. For the purposes of this manual, it is not practical to cover, in detail, even the most important damaging species. The corn earworm has been selected as an example.

The corn earworm is also known as the cotton bollworm, tomato fruitworm and soybean podworm. It varies in color from light green to almost black and has a yellow stripe down each side.

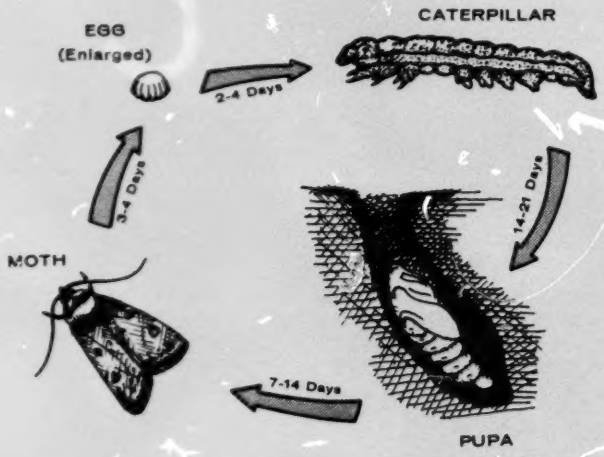

Figure 1. Corn earworm life cycle

Stiff hairs are scattered over the body.

The caterpillar ("worm") stage lasts from 14 days to 21 days but during the summer it will be much nearer 14 days. The entire life cycle lasts approximately 30 days at this time of year.

This insect is both a foliage and fruit feeder. The more important crops it feeds on

and parts damaged are as follows:

Corn - ear and whorl

Small grains and sorghum - head

Soybeans - pod and foliage

Cotton - bud and fruiting forms

Peanuts - foliage

Tomatoes - fruit

Tobacco - bud and other foliage

Pepper - pod

Okra - pod

Other Legumes - foliage and pods

There are many other foliage and fruit feeding caterpillars. Some of the more important species are fall armyworm, beet armyworm, "true" armyworm, tobacco budworm, loopers, granulate cutworm, tobacco hornworm and tomato hornworm.

b. Boring and Tunneling

This group of caterpillars contains fewer species than the preceeding group but some are very important pests. All types of crops are attacked by these pests.

The length of time that these pests are exposed after eggs hatch, and before they enter the plant is relatively short. To control these pests, insecticides must be timed during the period that the pest is outside the plant and before it begins to tunnel. A few species are

controlled by insecticides that are absorbed by the plant being attacked.

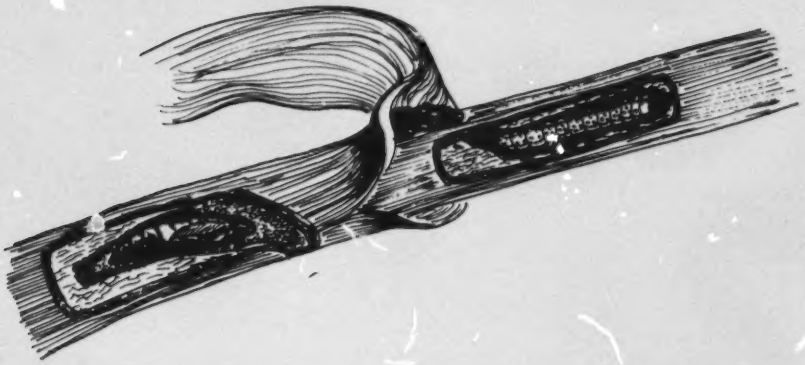

Figure 2. European corn borer caterpillar and pupa in corn stalk.

The European corn borer is an example of this group of insects. Egg masses are laid on the host plant. Eggs hatch and caterpillars feed for a short time on the exterior parts of the plant. Then they tunnel into the stalk where they remain until they are mature at about one inch long. The head is dark brown or black. The upper part of the body is gray to pink with rows of dark spots running lengthwise. The underside of the body is cream colored. Tassels or grain heads of damaged plants often break over.

European corn borers are important pests of corn and closely related grass crops such

sorghum and millet. They have also been found damaging about 200 other kinds of plants. Some of the more important ones are field peas, pimentos, cotton, and Irish potatoes.

Controlling this pest with insecticides is difficult. An effective systemic insecticide must be used or insecticidal sprays must be applied before the insect tunnels into plant parts where it remains until it is mature.

Some other boring and tunneling caterpillars are the hickory shuckworm, peachtree borer, lesser cornstalk borer and several kinds of leaf miners.

2. Beetles and Beetle Larvae

Beetles and their larvae, many of them referred to as grubs, are important pests of agricultural crops. In most instances, both the adult and larval stages damage plants in some way.

These insects have four stages in their life cycle. They are egg, larva (often called grub or "worm"), pupa and adult. Life cycles vary from less than 30 days to one or more years in length for different kinds of beetles.

Beetles usually feed on some exterior part of the plant such as the leaves, stem or flower while larvae may feed inside a plant part in the soil or on the outside of a plant part.

a. Weevils

Weevils are snout beetles. The long snout has biting and chewing mouthparts at the tip. Most of their damage is due to feeding on fruiting forms of the plants they attack, and laying eggs in these parts. When the egg hatches, the grub feeds on the inside of the fruiting form. Plant parts other than fruiting forms may be fed upon by adults but this damage is not very important.

The cotton boll weevil has been chosen as an example of this group of insects. It is a tan to dark gray or almost black beetle that is 1/8 to 1/3 inch long. Eggs are laid in a hole eaten in a square

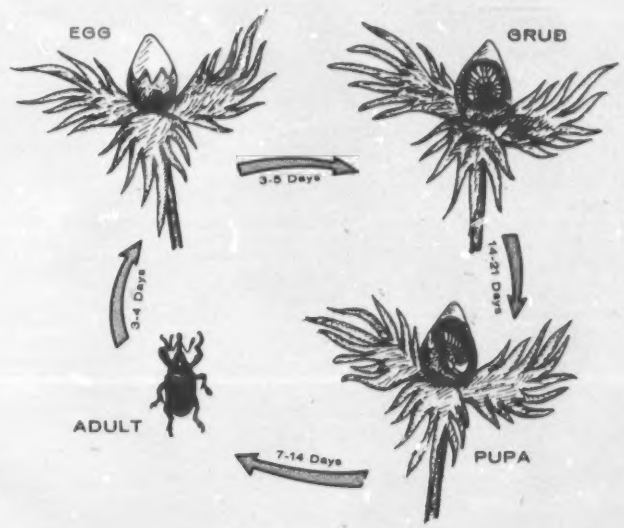

Figure 3. Boll weevil life cycle

or boll. The grub completes its development inside the square or boll where it changes into a pupa, and then to an adult that cuts its way out of the plant part. The entire life cycle requires about 21 days. It overwinters as an adult in ground trash or other protected areas.

Control of this pest depends on a series of well-timed insecticide applications intended to kill adults before they have time to mate and continue reproduction.

Some other weevils that are of economic importance in crop production are the cowpea curculio, pecan weevil, plum curculio and pepper weevil.

b. Soil Feeding Larvae

Soil feeding larvae are usually referred to as grubs or "worms". They feed on underground parts of plants stunting them to the extent that they never fully recover, or killing plants outright and reducing or destroying the stand.

The length of the life cycles of these pests are quite variable. Most require one or more years to complete the life cycle, while others require no more than one month under ideal conditions.

Control usually consists of a preplant, soil incorporated insecticide application. Some are controlled by insecticides applied to the soil surface after the crop is growing. It is important that the pest be identified and that a recommended insecticide be applied in the manner that is most effective.

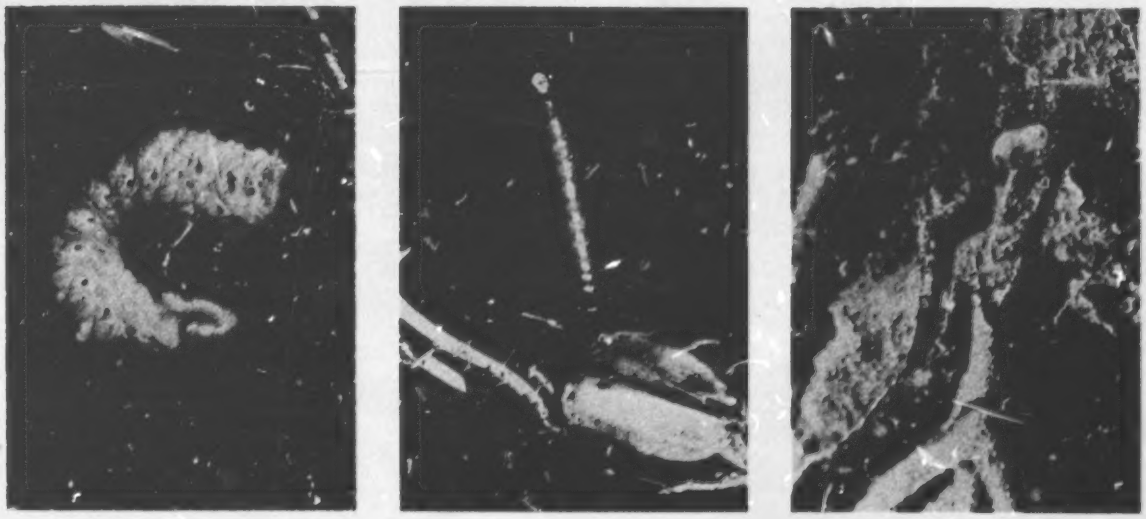

Figure 4. White grub, wireworm and whitefringed beetle grub.

This group is variable in appearance. Some insects that fit into this group are white grubs, wireworms, southern corn rootworm, bahia grass borer, whitefringed bettle grub and fleabeetle larvae.

c. Leaf Feeders

Many leaf feeding beetles are the adults of soil feeding larvae. Often the adult feeding is not considered to be of economic importance. Only those beetles that sometime require control will be included in this group. Fleabeetles and whitefringed beetles are two of the important pests in this group.

The Mexican bean beetle is an important leaf feeder. In contrast to the above mentioned pests, both the adult and the larva feed on foliage.

All four stages of the life cycle are found on the leaves of plants. This insect is primarily a pest of legumes.

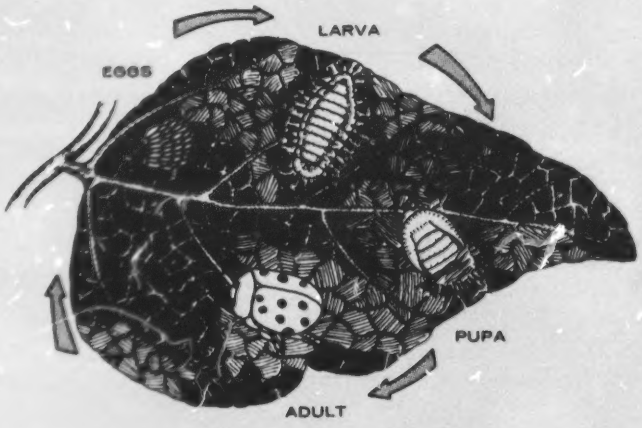

Figure 5. Mexican bean beetle life cycle.

Control of leaf feeding beetles requires a foliar application of a recommended insecticide.

3. Sucking Insects

This group includes a large number of different species of several types of insects. Most of them have a proboscis equipped in such a way that plant tissue can be pierced and juices sucked up for food. Some inject saliva in the feeding process which causes a deterioration of the plant tissue fed upon. Some feeding damage simply causes a malformation of plant parts fed upon. Others excrete a sticky material called honeydew. Sooty mold often grows on this honeydew on the leaf surface, reducing the penetration of sunlight and, therefore, photosynthesis.

Figure 6. Green stink bug life cycle

These insects have only three stages in the life cycle. They are egg, nymph and adult. There is no resting stage like the pupa that is present in insects that have four stages in the life cycle. The nymphal stage sheds the skin several times, gradually getting larger until it changes into the adult.

Many sucking insects can be controlled by the use of a preplant, or planting time, in-furrow, or soil incorporated applications of systemic insecticides. All can be controlled by recommended foliar applied insecticides. Some of these pests feed primarily from the undersides of leaves, making good coverage essential to effective control.

Some important pests that fit into the sucking insect group are aphids (plant lice), thrips, stinkbugs, whiteflies, plant bugs, leafhoppers and spider mites (not an insect).

B. Diseases and Nematodes

Broadly speaking, a plant is said to be diseased when it is continuously affected by some factor which interferes with its "normal" structure or activities; disease usually produces some outward signs and/or symptoms. The inclusion of the word "continuously" excludes such things as insect injury.

Disease is a term usually reserved for those problems caused by parasites: Fungi, bacteria, nematodes, viruses, mycoplasmas and parasitic seed plants. Some disorders caused by things other than parasites are often confused with diseases. These problems are caused by such things as unbalanced fertility, toxic chemicals, air pollution, etc. They often resemble diseases caused by certain parasites. For example, certain types of spray burn look much like some leafspot diseases. In many instances, it is difficult to determine the cause without several days of laboratory work.

Symptoms and signs of a disease are the basic keys to plant disease identification. A symptom of a disease is the reaction of the host plant to invasion by the parasite or injury from the non-parasitic factors: spots on the leaves or wilting. A "sign" is physical evidence of the pathogen: visible growth of fungus spores, for example.

All disease symptoms and signs are caused by an interaction between the host plant, the pathogen

(parasitic causal agent) and the environment. Some specific pathogens are able to attack a number of different plant species and the symptoms of the disease may be entirely different on each different plant. Diseases caused by nematodes may have no visible above ground symptoms if soil moisture is adequate.

There are over 80,000 different parasitic diseases of plants. Of course, no crop has this many diseases. Some have only one or two common diseases; others have many more. Tobacco has over 70 different described diseases. Only a few of these commonly occur and cause economic problems, but the fact that the less common diseases do occassionally occur complicates accurate disease diagnosis. Quite frequently, a plant may have two or more diseases at the same time.

Accurate identification and diagnosis is an art as well as a science and experience is important. This outline is not intended to make anyone an expert in identifying diseases. In an outline of this type, it is impossible to cover even the major disease problems of individual crops. The discussion is to acquaint you with the general symptoms that occur as a result of disease and, for example, whether the symptoms are a result of the pathogen attacking the leaves or the roots.

Fungus and bacterial diseases are grouped into symptom classes; virus and nematode diseases are covered under the causal agent.

1. Leaf Diseases

These diseases occur primarily on leaves, but some may also occur on stems and/or fruit. Leaf diseases are the most common diseases of most plants. They are usually controlled with fungicides and resistant varieties. Although leaf diseases are described under several different symptom types, keep in mind that differences are not always clearcut and there are many names for leaf diseases other than those given, which can be confusing.

a. Leaf Spots

Leaf spots (other names: anthracnose, scab, leaf blotch, shot hole, are usually rather definite spots of varying sizes, shapes and colors. There is nearly always a distinctive margin. Sometimes the spot is surrounded by a yellow halo, which may be caused by bacteria or fungi. If caused by a fungus, there is nearly always fungus growth of some type in the spot, particularly in damp weather. This may be tiny pimple-like structures, often black in color; or a moldy growth of spores. It is often necessary to use a hand lens to see these structures. If the spots are numerous or close together, diseased areas may join together to form irregular areas called "blotches". The common names of leaf spot

diseases may be general, such as, peanut leaf spot; descriptive, such as zonate leaf spot; or names after the fungus, such as Septoria leaf spot.

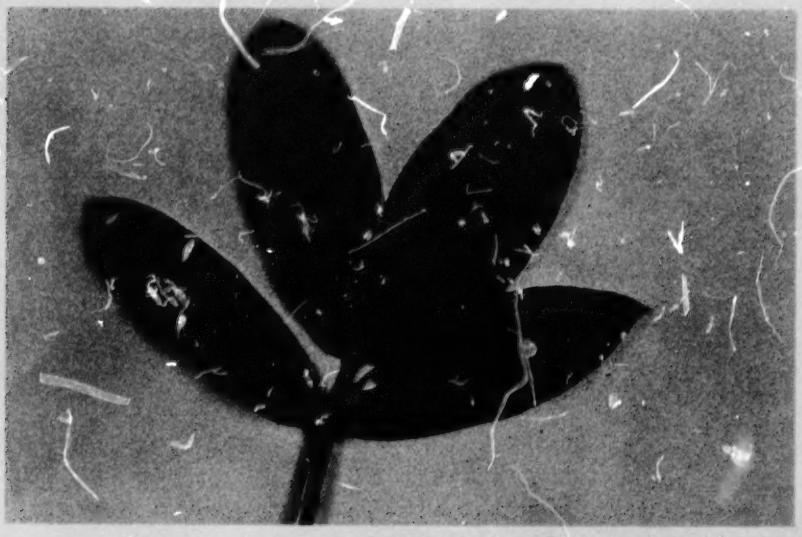

Figure 7. Cercospora leafspot of peanuts is typical of leafspot diseases: a dark colored, more or less oval shaped spot. The light colored halo around the dark spot occurs with many leafspots.

b. Leaf Blights

Leaf blights are generally larger diseased areas than leaf spots and more irregular shaped. Usually the common name includes the word "blight" such as Southern corn leaf blight or early blight. (see Figure 8.)

c. Rusts

Rusts often produce spots similar to leaf spots, but the spots are called "pustules". Rust pustules are bright yellow, orange-red, reddish-brown or black in color. The pustules

are usually raised above the leaf surface; and when rubbed with a white cloth, a colored deposit the same color as the pustule can usually be seen on the cloth. In severe cases, the leaf withers and dies rapidly. Some types of rust also occur on stems. Rusts are most common on grains and grasses.

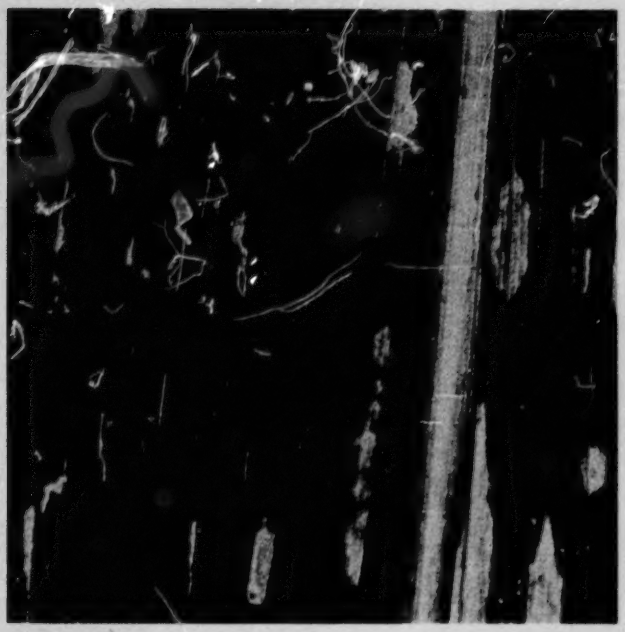

Figure 8. Helminthosporium leaf-blight of corn. The diseased areas are irregular in shape and generally larger than leafspots.

Figure 9. Leaf rust of small grain. Each pustule is a mass of brick-red spores.

d. Powdery Mildew

Powdery mildew is a superficial, white to light grayish, powdery to mealy growth on leaves, but also may occur on stems and flowers. Affected leaves usually turn yellow, wither and die rapidly. Most common on cucurbit-type

vegetables, small grains and pecans.

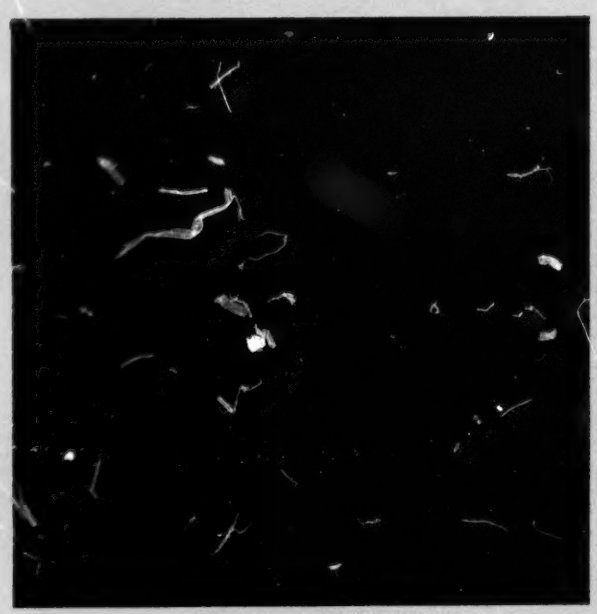

Figure 10. Powdery mildew (of cantaloupe) diseases are characterized by a superficial white moldy growth on the leaves.

e. Downy mildew

Downy mildew is pale green to yellow areas on the upper leaf surface; light gray to purplish moldy growth on under surface of the leaf. Important on some vegetables. (see Figure 11.)

2. Wilts, Root and Crown Rots

These are three distinct types of diseases, but they often show similar overall symptoms (wilting and death of the plant). However, other symptoms are not similar and close examination of a plant with wilting symptoms will nearly always allow you to determine if

it is a wilt, a root rot or crown rot. These diseases are usually soil-borne (the causal organism is already present in the soil when the host is planted) as opposed to most other diseases (except nematode diseases) which are usually spread through the air. Some of these diseases may be controlled through the use of soil fungicides and/or soil fumigants, but most are controlled with resistant varieties and cultural practices. Good controls are not available for many of these diseases.

Figure 11. Downy mildew. This downy mildew disease of tobacco is called "blue mold" because of the typical greyish to blueish growth of fungus on the underside of the leaf.

a. Wilts

Most diseases that are called wilts are caused by two fungi: Fusarium and Verticillium and a bacterium, Pseudomonas. All of these cause wilts on a wide range of crop plants. Pathogens that cause wilt diseases enter the plant through the roots. Some of the roots may

be black and rotten in the early stages of disease, but the extensive root rotting like root rot diseases does not occur until after the plant is dead. When a stem of a plant with one of these diseases is cut lengthwise, a light to dark brown streaking can be seen in the stem. It is often difficult to determine which of these wilt diseases a plant may have, but certain distinguishing characteristics will usually make a reasonably accurate diagnosis possible. Verticillium wilt normally occurs only in cooler areas with lower soil temperatures than does the other two wilts. Plants with Fusarium or Verticillium wilt are usually slower growing than healthy plants and may show stunting effects before wilting occurs. The lower leaves usually turn yellow and wilt first, then yellowing and wilting slowly pro-

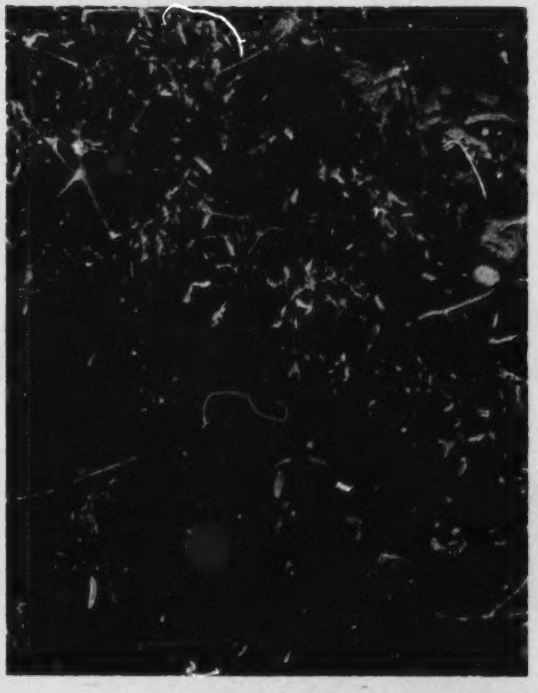

Figure 12. Fusarium wilt of tomatoes, above ground symptoms of yellowing and wilting.

gress up the plant. Several days to a few weeks may elapse between first evidence of wilting and death of the plant. In contrast, plants with bacterial wilt usually die within a few days after the first wilt symptoms are seen. Also plants with bacterial wilt often exhibit a one-sided wilt: leaves or branches on one side of the plant are wilted while the opposite side appears healthy. Fusarium wilt is often a "complex" or interaction between the fungus and nematodes: The fungus may be present in the soil, but will not cause disease unless nematodes attack the roots. However, Verticillium and bacterial wilts are usually more severe when nematodes attack the roots. Fusarium and Verticillium wilt are important diseases on cotton and many

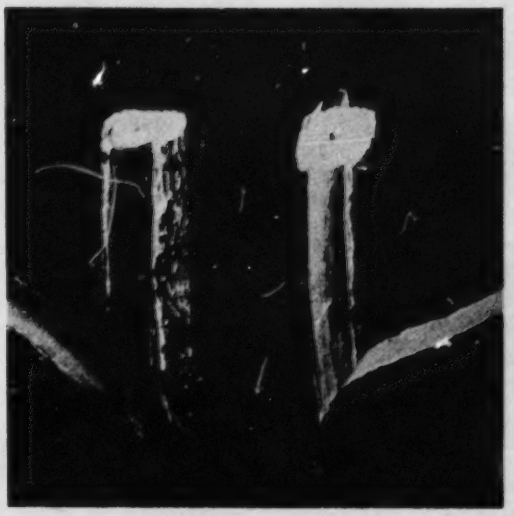

Figure 13. Fusarium wilt of cotton shows the brownish discoloration in the stem typical of wilt diseases as compared to a healthy stem on the right.

vegetables; bacterial wilt is important on tobacco and most vegetables.

b. Crown Rots

This includes those diseases in which the casual organism attacks the plant at/or near the soil line. Crown rots are called various names such as Collar rot, Stem blight, Stalk rot, Southern blight, etc. Affected plants are generally, at first, unthrifty with leaves smaller and lighter green than normal. Leaves usually turn yellow and in advanced stages of disease, wilt and die. The crown or base of the stem will be water-soaked, discolored or decayed. With some diseases, this area may dry rot and become shredded. A moldy growth and various colored fungus fruiting bodies often form in this diseased area. Most crops are affected by one or more of this type of disease.

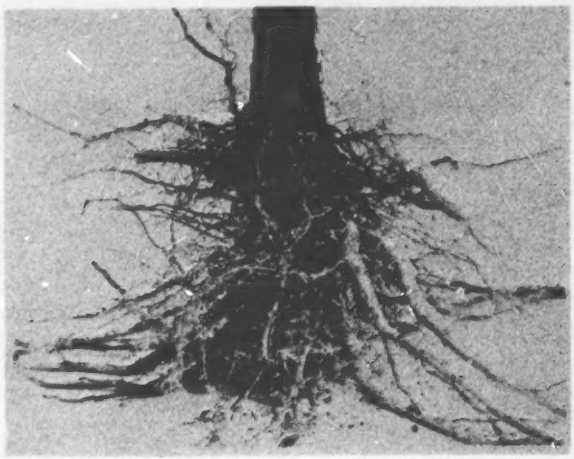

Figure 14. Southern stem rot. Notice that the stem is diseased while the roots are still white and apparently healthy.

c. Root Rots

Above ground symptoms of these diseases are variable. Some plants may show wilt type symptoms and die rapidly; others are yellow, stunted, slow growing and may not die for some time after the first symptoms are seen. Roots are reduced in size and will be light brown to black in color and rotten. All plants are affected by root rots.

Figure 15. Root rots are characterized by a lack of small feeder roots and a dark discoloration of the roots that are present.

3. Stem Cankers

Stem cankers are diseased areas on main stems or branches which are definite discolored areas. These areas may be irregular or oval in shape; they may be sunken or swollen. Some cankers may crack open and expose the wood underneath. The foliage on stems with cankers is usually slow growing and reduced in size. Infected stems often start growth later in the spring than normal stems. Sometimes the tip of infected

stems die back. Infected branches and plants may not die for several months or even years after disease first develops. Stem cankers are most important on woody perennial plants. These diseases are controlled with fungicides and sanitary practices.

Figure 16. A definite discolored area on the stem is characteristic of stem canker diseases. Tip dieback sometimes occurs with these diseases.

4. Fruit Rots

These diseases are caused by many different fungi and bacteria and occur on all types of fruit. The symptoms vary from a more or less superificial fungus growth on the external surface to a complete, mushy rot. Fruit rot may develop while the fruit is still on the plant or in shipment and storage. These rots may be small scattered spots or involve the entire fruit. Many of these spots may be sunken below the surface and contain spores or other fungus fruiting bodies. Some types of fruit rot may cause a shrivelling of the fruit and dry rot. Many are specific diseases only on certain fruit; others may occur on many different fruits. One of the most important of all

Figure 17. Sooty blotch (the larger irregular areas) and fly speck (the tiny specks) are fruit rots which are superficial fungus growth.

Figure 18. Brown rot of peach is a type of rot which may occur while the fruit is still on the plant. The tissue under the moldy fungus growth is completely mushy and rotten.

plant diseases is a fruit rot call Bacterial soft rot which occurs on almost all fruit. This disease usually occurs only after an injury and is characterized by a rapid, mushy or watery, foul-smelling rot. Fruit rots are controlled to some extent by fungicides, sanitation and proper storage conditions.

5. Seed and Seedling Diseases

By definition, these diseases occur on plants only until about one to two weeks after seedling emergence. Seed diseases are caused by fungi which may be on the

seed at planting or by the fungi in the soil. They are often responsible for non-emergence or slow emergence. Seed may have a dry rot or a wet, mushy rot. Seedling diseases occur after germination until shortly after emergence. If the disease occurs before emergence, the seedling may rot before it has a chance to get out of the soil. After emergence, seedling stems may be attacked right at/or slightly below the soil line.

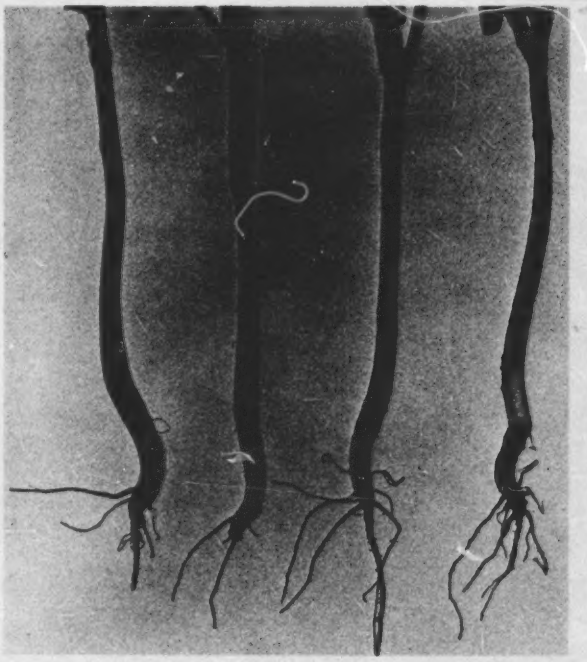

Figure 19. Rhizoctonia seedling disease commonly occurs on many plants and is characterized by dark sunken areas at the groundline down to the root tip.

There are two general symptoms which occur at this time: brown to reddish-brown or black cankers at the soil line which may or may not completely girdle the stem; if complete girdling occurs, the seedling falls over and dies; with partial girdling, the plant may continue to live, but will be stunted. The second type of symptom is a soft, watery rot at the soil line and eventually, the entire seedling rots. Seed and seedling diseases are most common in cool, wet soils. They are controlled by planting in a warm soil, seed treatment and/or in-furrow fungicides.

virus Diseases

This group includes a very wide range of diseases caused by viruses, and certain diseases once thought to be caused by viruses but now have been shown to be caused by a group of organisms called Mycoplasma. Almost all plants may have one or more of this type disease. There is a very wide range of symptoms. It is often difficult to distinguish between virus diseases and certain diseases caused by fungi, bacteria and nematodes as well as problems caused by environment, nutrition and other factors. It is impractical to describe all the different symptom types but some of the more common symptoms are as follows: Mosaic: a light green to yellow leaf mottling usually accompanied by abnormal leaf growth; Vein banding: a light green to yellow band around the leaf veins which may turn dark with time: Ring spot: alternating rings of light green or yellow bands with the normal green of the leaf. Yellows: the entire plant or some parts uniformly yellow. Stunting

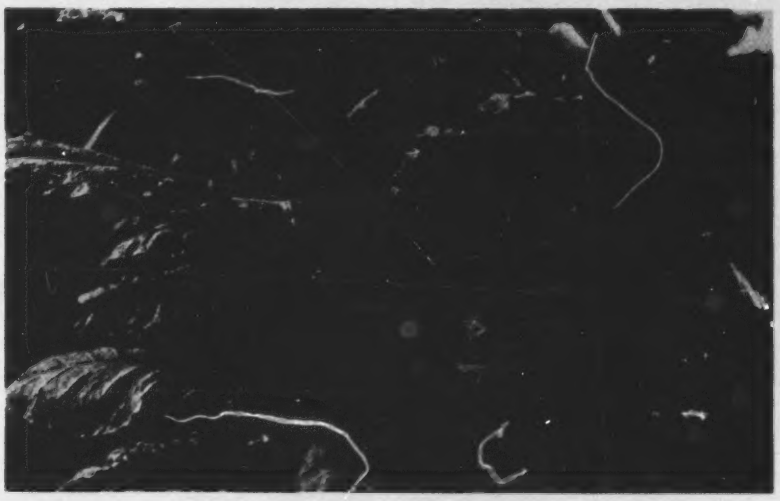

Figure 20. Tobacco mosaic is one of the most common mosaic-type viruses and occurs on many plants. The light and dark areas produce the typical mosaic symptom.

usually accompanies all of the previous symptoms, or stunting may be the only symptom. Some virus diseases do not show any visible symptoms other than a yield reduction.

Figure 21. Yellow, stunted plants are often symptoms of virus disease.

Many virus diseases are transmitted from plant to plant by insects, some are transmitted by grafting and others are transmitted by mechanical means. Virus diseases are difficult to control. Some are controlled by resistant varieties, using virus free seed or planting stock and controlling the insects that transmit the disease.

7. Nematode Diseases

All plants are attacked by one or more types of nematodes. Diseases caused by nematodes are one of the most important groups of plant diseases. Nematodes cause several hundred million dollars loss in the United States annually. It may well be that if we could accurately measure losses from these pests, losses would be considerably higher. This is because nematode damage often goes unrecognized or is blamed on some other problem.

All important nematodes feed on plant roots. This directly interferes with water and nutrient uptake. This

root injury causes above-ground symptoms similar to those produced by other conditions that damage the root system. Plants frequently appear to be suffering from lack of moisture or fertilizer, even when water and fertilizer are adequate. Typical above-ground symptoms are stunting, yellowing, loss of vigor, general decline and eventual death of plants when nematodes occur in high populations.

Figure 22. Above ground symptoms of nematodes are stunted plants, occurring in scattered areas of the field.

Nematode injury in the field is rarely uniform. Symptoms usually appear in small, scattered areas. Nematode symptoms are usually more obvious when soil moisture and fertility are low. Nematode damage to root systems in the presence of these diseases often cause more severe disease symptoms.

When nematodes are suspected, you should always examine the roots and take soil samples.

To examine the roots, always carefully dig up the plants. Never pull the plants up. Nematode symptoms on the roots depend on the type of nematode causing the injury. Usually the symptoms will be one or more of the

the following: galls or knots, tiny brown to black lesions, stubby-roots and complete loss of feeder roots.

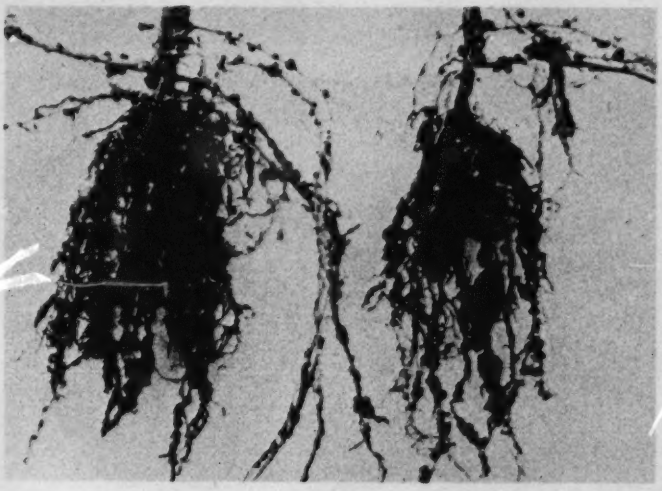

Figure 23. Root-knot nematodes cause knots or galls on the roots.

Many other problems can cause symptoms similar to nematodes. For this reason, always take soil samples when nematode injury is suspected.

Take samples from around the edge of the suspect area, within the root zone. Use a soil sample tube and take soil down to a depth of 6-8 inches. Make at least 10 random probes per acre. Mix all of the soil in a bucket, put about one pint of soil in a plastic bag and send to the nematode assay lab through your county extension agent.

Figure 24. Nematode types other than root-knot often cause a reduced root system or complete lack of feeder roots.

Nematodes are controlled with cultural practices, resistant varieties and nematicides.

C. Weeds and Weed Control

Weeds are a major factor reducing crop yields. Weeds reduce yields through competition for light, moisture and nutrients. Heavy weed growth present at harvest also can cause severe harvest loss due to inefficient operation of harvesting equipment.

From the standpoint of response to herbicides, weeds can be grouped into four broad categories. For specific response of weeds to various herbicides used on row crops, refer to state extension recommendations.

1. Perennial and Biennial Weeds

Weeds of this category are generally difficult to control and require special control procedures. Often treatment procedures must be applied two or more years in row crops, pastures and tree crops to achieve satisfactory control. Examples: a. Perennials - johnsongrass, horsenettle, wild garlic, curly dock, maypop passionflowers. b. Biennials- common mullein and wild carrot. (see Figure 26)

Figure 25. Horsenettle. A, Habit B,flower; C,berries D,seeds. Perennial weeds such as horsenettle often are difficult to control in cropland.

Figure 26. Wild Carrot. A, Habit; B, flowers; C, schizocarp; D, cross-section of fruit. Biennial weeds such as wild carrot complete their life cycle in two years.

Figure 27. Large crabgrass. A, Habit; B, florets, front and back; C, caryopsis. Annual grasses such as crabgrass are generally controlled by soil-applied herbicides.

2. Annual Grasses

Weeds of this category are usually readily controlled with preemergence herbicides (preplant incorporated or surface applied). Certain weeds of this category are more difficult to control than others, for example: Texas panicum and fall panicum are controlled more readily with certain preplant incorporated herbicides (dinitroaniline herbicides) than with surface applied herbicides. Examples: crabgrass, goosegrass, Texas panicum, fall panicum, sandspur, broadleaf signalgrass, etc.

3. Small-seeded Broadleaf Weeds

These weeds are generally controlled well with herbicides which control annual grasses. Examples: pigweeds, lambsquarters, Florida pusley, prickly sida, Florida beggarweed, etc.

Figure 28. Redroot pigweed. A, Habit; B, pistillate spikelet; C, utricle; D, seeds. Small-seeded broadleaf weeds such as pigweeds are generally controlled by soil-applied herbicides.

Figure 29. Common cocklebur. A, Habit; B, seedling; C, bur; D, seed. Large-seeded broadleaf weeds such as common cocklebur are often difficult to control.

4. Large-seeded Broadleaf Weeds

These weeds are not consistently controlled by preemergence herbicides (preplant incorporated or surface applied). Presently, these weeds and perennial weeds are the most difficult to control in most crops. Examples: cocklebur, sicklepod and jimsonweed.

III. PESTICIDES

Pesticides are used to reduce populations of damaging pests. Unfortunately, pesticides sometimes have undesirable effects on non-target organisms. Pesticides should only be used when benefits from such use are greater than the undesirable effects.

A. Formulations and Sources of Information

Pesticides are formulated as emulsifiable concentrates, liquid concentrates, flowable liquids, wettable powders, soluble powders, dusts, granules and baits. Generally, it doesn't matter which type formulation is used as long as it can be uniformly applied to the area where it is needed, in the concentration required. In some instances, the type of formulation is important. State extension recommendations usually explain the need for a specific formulation. All states have publications available through county Extension offices that are excellent sources of information on pesticides recommended, how they should be applied, safety precautions and restrictions and how to best time applications. State Extension Specialists are available through county offices to assist with any problems that cannot be handled by the local staff.

The label on the pesticide container gives most of the information needed in using the pesticide. It should be carefully studied before each use of the chemical.

B. Application

Pesticides are applied in almost every conceivable manner. Spraying is by far the most common method. How-

ever, dusting granule application, spreading a bait and releasing a chemical that turns into a gas and fumigates are other methods used. Pesticides are applied broadcast, in bands, directed to the plant bud, directed under the canopy, to the soil surface, mixed uniformly into the soil and even turned down. The type application needed depends on the pest that is to be controlled, and the method that has proven most effective. Often more than one pest needs to be controlled with a single application of pesticide and a compromise method may be chosen that is the best for the complex, though not as good for one or most pests present. Extension workers can usually furnish information on the best method of application to accomplish the desired goal.

C. Insecticides

Insecticides are pesticides used to control insect pests. Most of the commonly used insecticides are classified as chlorinated hydrocarbons, organo phosphates or carbamates. They are synthetic organic chemicals and are classified according to their chemical structure.

In general, chlorinated hydrocarbons have a longer residual life than the other chemicals. As a group, chlorinated hydrocarbons have a lower acute toxicity to warm-blooded animals than organo phosphates and carbamates. They have been more widely used in past years but are being depended on less frequently in recent years. Their long residual nature, the fact that they are stored in

fatty tissue, and because they undergo biological magnification in natural food chains, are some of the reasons for using them less. Such chemicals are DDT, chlordane, aldrin, dieldrin, endrin, BHC, lindane and toxaphene are examples of this group of chemicals.

Organo phosphates are generally much less persistent in the environment than chlorinated hydrocarbons. Many of these are highly toxic to warm blooded animals, and, therefore, much care should be exercised in mixing and applying them. As a group, they are probably the most commonly used insecticides today. Some of these chemicals are systemic when used on crops. Some of the more commonly used organo phosphate insecticides are methyl parathion, parathion, malathion, disulfofon, phorate, diazinon, dimethoate, fensulfothion, prophos, and monocrotophos.

Carbamates insecticides are the newest group to gain general usage. Most of the more useful of this group are highly toxic to warm blooded animals. Several of them are effective systemically. Most are not persistent in the environment. Some examples of the carbamate group are carbaryl, carbofuran, methomyl and aldicarb.

D. Disease Control Chemicals

Pesticides used to control plant diseases are classified as Fungicides, bactericides and nematicides.

1. Fungicides

Fungicides are used to control diseases caused by

fungi. Fungicides are used as seed treatments and soil treatment, but by far most of the fungicide usage is as foliage fungicides. To be effective, most must be applied before disease occurs. These are protectant fungicides. There are a few eradicant fungicides, primarily those that control powdery mildew diseases.

Fungicides are classified as inorganic and organic.

Inorganic fungicides include sulfur, copper-sulfate, copper oxide and Bordeaux mixture. Generally, these fungicides are not as effective as the newer organic fungicides. They are often phytotoxic. Although they are still used to some extent, they have largely been replaced by organic fungicides.

Organic fungicides commonly used are maneb, zineb, captan, benomyl and chlorothalonil. These are fairly broad spectrum and will control most leaf diseases. There are a number of others, such as dinocap used exclusively to control powdery mildew, which have limited use for specific diseases or crops.

Fungicides as a group are not highly toxic to warm blooded animals nor do they persist in the environment for any length of time. However, there are some exceptions to this.

2. Bactericides

Bactericides are used to control diseases caused by bacteria. However, there are few bactericides. Most inorganic copper fungicides are also bactericides. Streptomycin is the only specific bactericide but its use is limited.

3. Nematicides

Nematicides are used to control nematode diseases. As such, they are applied to the soil in some manner.

Fumigant nematicides are usually liquids which are injected into the soil. After injection, they form gases. These gases move upward and outward to form a "U"-shaped fumigated area. Fumigant nematicides include DBCP, ethylene dibromide, dichloropropanes, methyl bromide and chloropicrin.

Non-fumigant nematicides are liquids or granules which are applied to the soil surface and incorporated into the soil. Some may move downward with water movement. The non-fumigant nematicides are fensulfothion (Dasanit), ethoprop (Mocap), carbofuran (Furadan) and aldicarb (Temik).

Nematicides, particularly the non-fumigant type, are toxic to warm blooded animals.

E. Herbicides

Herbicides may be classified as:

1. Selective

Herbicides in this group kill some plants while having little or no effect on others. The selective nature of these herbicides permits their use to eliminate weeds with little or no adverse effect on crops. Selectivity is primarily based upon differences in absorption, translocation, morphology and physiology in plants. Some examples are atrazine, 2,4-D, trifluralin and alachlor.

2. Non-selective

Herbicides in this group kill vegetation without

regard to species. Representative examples are paraquat, prometryne and bromacil.

3. Contact

These herbicides kill or effect only the plant tissues which are covered in application. They produce plant kill within a few hours to a few days after application. Certain of the contact herbicides may provide residual control as well as contact kill (linuron, diuron, etc.) while others provide little or no residual control (dinoseb, paraquat).

Contact herbicides may be applied as directed or semi-directed sprays to avoid or minimize contact with crop foliage. This permits removal of weeds with minimal crop injury. (See Section II)

4. Translocated

Herbicides in this group are absorbed by plant foliage and/or roots and are translocated throughout the plant. They generally require several days to several weeks to produce plant kill. Some examples are 2,4-D, 2,4-DB and dalapon.

a. Root Absorbed Herbicides

Root absorbed herbicides are generally most effective if applied before weed seed germination. Generally higher rates of these herbicides are required to control established weeds than is required for control of germinating weeds.

These treatments are highly effective for control of annual weeds in cropland. Some representative examples are atrazine, cyanazine and trifluralin.

b. Foliage Absorbed Herbicides

Foliage absorbed herbicides are used for control of both annual weeds and established perennial weeds. Certain of the foliage absorbed herbicides are highly effective treatments for control of established perennial weeds. Examples: dalapon for control of perennial grass and 2,4-D, 2,4,5-T, etc., for control of perennial broadleaf weeds.

F. Special Problems

1. Pre-harvest and Re-entry Intervals

Many pesticides are restricted by a minimum time from last application to harvest. This time requirement is known as the pre-harvest interval. The label and Extension pest control publications furnish needed information on this restriction. Pre-harvest intervals should be carefully observed to prevent harvesting an illegally contaminated product.

The minimum time between applying a chemical and workers entering the treated area is known as the re-entry interval. This restriction is presently required for only some pesticides that are highly toxic to warm blooded animals. Re-entry intervals should be carefully observed.

2. Phytotoxicity

When a chemical burns a plant to which it is applied, it is said to be phytotoxic (plant toxic). If the plant is a weed and the chemical a herbicide, the result is good, but usually the word phytotoxic is used when a pesticide adversely affects plants. Phytotoxicity may occur due to drift onto non-target plants, excessive rates, mixing of chemicals that are not toxic when used alone, and using chemicals in a more concentrated form than is desirable. Certain weather patterns may cause or increase the amount of phytotoxicity. Exceptionally bright, hot, dry weather following a period of cooler weather is such a situation. It is not too unusual to get some phytotoxicity when using pesticides in accordance with recommended practices. It is unusual to have a severe phytotoxicity problem under these circumstances.

To avoid phytotoxicity, apply chemicals within recommended rates. Do not mix chemicals unless the label indicates it is alright. Time applications according to recommendations. Use recommended water rates.

3. Residues

The amount of a pesticide that remains after application is the residue. The ideal pesticide would be one that is residual enough to give control of a pest for the length of time needed and then break down into completely harmless chemicals. Unfortunately, this is not the case with most pesticides. The long residual nature of chlorinated hydrocarbons is one of the main

reasons they are being used less. Usually a tolerance is set for each chemical that is registered on a crop. It is expressed in parts per million (ppm). The residue that remains on the harvested crop cannot exceed the tolerance that was set when the pesticide was labeled. This has a direct relationship to the pre-harvest interval. Registered and recommended rates should not be exceeded because the residue may exceed the legal tolerance.

The residue of pesticides in soils may create problems. If a chemical is legally used on one crop, and it is not legal on the succeeding crop, an illegal residue may result. See Section III on contamination of soil and water for additional information.

4. Environmental Contamination

The long residual chlorinated hydrocarbon insecticides are the most likely chemicals to cause contamination of the environment for an extended period. These chemicals should be used in strict accordance with recommendations. If possible, avoid using a broadcast treatment over a very large area, such as an entire county or several counties. Before undertaking large-scale control efforts, consult governmental agencies about recommendations, precautions and restrictions.

a. Non-target Injury and Community Problems

Care should be exercised not to contaminate non-target areas when applying a pesticide. This is particularly true of food and feed crops,

bodies of water, apiaries, woodlands, and urban areas. Information on the least hazardous recommended chemical to use, where there is danger of contamination, can be obtained from county extension offices.

Drift is probably the chief culprit contributing to contamination of non-target areas. Pesticides should be applied when there is little or no wind. Under no conditions should pesticides be applied if wind exceeds 10 miles per hour. Using extremely low volume and air delivery spraying systems increases the problems of drift. Some pesticides, particularly herbicides, may badly damage or completely destroy some crops if they are allowed to drift onto them. The phenoxy herbicides(2,4-D, 2,4,5-T,etc.) are examples of the type chemicals that can be very damaging.

Such precautions as spraying when there is little or no wind, using the least volatile forms of dangerous chemicals, and avoid breaking spray into real fine particles will help prevent these problems.

b. Contamination of Soil and Water

When pesticides are being used, care should be taken to prevent undue contamination of the soil and bodies of water. Select the pesticide that is least likely to cause contamination

problems.

For example, carefully mark each swath in order to avoid a double application. Some herbicides and long residual insecticides may have a carry-over effect if excessive rates are used. This could contaminate or destroy subsequent crops.

When bodies of water are in close proximity to the area being treated, select the recommended chemical that would be least likely to cause contamination of the water. Apply the chemical when there is no wind, or when the wind is in the direction to drift the chemical away from the water. Do not apply the chemical when heavy washing rain is probable.